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Utilising disaggregated energy data in feedback designs – the IDEAL project

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Introduction

Conventional energy feedback displays still typically rely on ‘information deficit’ models of energy behaviours, in which users are provided with more detailed or engaging information about their current and historic energy use and associated (financial and carbon) impacts. The underlying assumption is that providing this information will enable users to make more informed, ‘rational’ decisions about energy-using behaviours, with the added assumption that they will then choose to use less energy. This approach to energy feedback is still the standard design as specified, for example, in the minimum feature set for in-home displays in the UK Smart Metering Programme (Pullinger, Lovell, & Webb, 2014). However, there is an increasing interest in processing this energy data in ways that may make it more interesting, engaging and useful for the user. Such designs are being developed and evaluated in academic research and are increasingly appearing in commercial feedback systems.

One new strand of research has taken energy feedback out of the conventional in-home display to incorporate it into a variety of alternative physical artefacts, ranging from artificial trees whose branches light according to energy use (Piccolo, Baranauskas, & Azevedo, 2016) to similarly enhanced clocks and polar bears (Verdezoto, 2016), aiming to render energy use more visible in everyday life as a way to encourage behaviour change (Hargreaves, Nye, & Burgess, 2013).

A second strand focuses on the potential to process energy and other sensor data to produce additional feedback for the end user, whilst still using an in-home display as the main interface. This might involve providing more detailed information displays, such as by disaggregating energy data to present energy use by appliance, or to link energy use to the practices being performed in the home (Goddard, Moore, et al., 2012). In addition, it might involve processing the data further, to provide actionable advice about how best to alter the energy-using practices of households. These approaches aim to automate some of the complex data processing steps that are otherwise left to the end user, i.e. the steps required to transform aggregated data on energy use into a form that makes it clearer to the user what changes in practices they could make to reduce their energy use.

The IDEAL approach to feedback

Our approach to designing the feedback system considers three criteria:

1. Practice theory. We start from the premise that feedback should be considered a form of story-telling or conversation, in which the natural conceptual units for the user are the practices they engage in – doing the laundry; heating/cooling/ventilating for comfort and health; preparing meals for sustenance and sociability; and so on. Feedback systems will be more effective if the communications they engage in are better aligned with the language and conceptualisations of practices natural to the users.

2. Engagement through enablement. A feedback system will be more effective if the information it provides answers directly questions the user has. We select participants who are already motivated to learn about and/or reduce their energy use. An analogy might be an obesity-study which focussed not just on people who are obese, but the subset who are motivated to join a study that aims to help them reduce weight. We are not designing a feedback system to motivate energy demand reduction, but to be of assistance to users who already are so motivated: an enabler.
3. Co-design of the feedback system. The feedback system is a computational artifact for the home, and as such its design should draw upon best practice in software engineering and user experience design. Our approach is informed by the tenets of extreme programming, human-computer interaction, and living labs.

Practice-based Feedback

We operationalise practices in the feedback system by organising them into four categories:

- Laundry
- Cooking
- Personal washing
- Thermal comfort

Obviously people engage in many practices (e.g., leisure, entertaining, travel) beyond the ones in these four areas, but these are the ones we identified as (a) being significant in their use of energy and opportunity for participants to modulate that use, and (b) amenable to our intervention given the sources of data and communication channels available to us.

Within each of these areas, there can be multiple sub-practices which may stand alone or be linked. As an example, “doing the laundry” will involve all of “putting an item in the laundry basket”, “washing clothes” and “drying clothes”, and possibly “removing creases”, each of which may be manifest in different non-exclusive ways (e.g., “tumble drying”, “spinning”, “hanging on the drying rack” and “hanging on the washing line”). Our aim is to create and study a feedback system that is aligned, in both form and content of interactions, with practices as we discover them to arise in our study households.

Engagement through Enablement

Engagement of participants is a key factor in the effectiveness of advice-giving systems [citation]. We feel that “feedback” is not a good descriptor for the kind of system we are aiming at. The system should engage the participants in an ongoing dialogue that is always under the control of the participants but can be both participant and system driven – more of a consultant or advisor. To structure this dialog, and as a form of engagement, we plan to run “themes” in the four areas listed above (laundry, etc). Theme activities will include:

- announcement and survey of current form of practices

- rating of energy/efficiency tips such as “*High-speed spinning makes drying cheaper and faster*”
- a practice disruption “game” such as “*Can you try wearing some items for once or twice more before washing?*”
- in a subset of households, a focus group to explore practices and co-design the user interface (see below).
- personalised information about current practice as observed by the system, with suggestions for making the practice more efficient in energy and cost terms (and often in time as well).

Enabling participants to change practices to make them more efficient can require some detailed knowledge of current practices – for example it is of little use to advise a participant that washing clothes on a low-temperature cycle is faster and cheaper than a high-temperature cycle, if the participant/household is already washing on low-temperature cycles. We identify key aspects of practices that can in principle be inferred from the data available to our system, and use various computational methods to automatically generate advice and responses to participants. One of the great research questions is what are the best inference methods in these kind of tasks, where we have multiple streams of time-series data from diverse sensors, as well as more intermittent but focussed information from participant interaction with the system.

Co-design of interfaces

Several strands of research and practice are converging on the principle that effective computational systems that are embedded in human activities can be best designed, implemented and evaluated with a representative sample of the people who are likely to engage with the system. Extreme programming is a software-engineering process for ensuring that a computational system matches the problem it is trying to solve, through rapid cycles (e.g., monthly) of needs elicitation, design, implementation, rollout and evaluation. Human-computer interaction studies emphasize the need for good understanding through controlled studies of what kind of information presentation and engagement strategies work well in practice (Winterboer, Tietze, Wolters & Moore, 2011). Living labs take these ideas further and engage the users in the actual design process as well as the evaluation, and can be run in cycles.

We use these approaches in creating our feedback system. One cohort of households (40-50) will be involved in focus groups to explore current practices, and in design sessions to explore possible user interface issues including what questions are of interest (e.g., “I want to understand how much low-temperature washing might save me in a year”, how the answers should be formed (e.g., “icons and graphics” and delivered (e.g., “on the tablet but with a text message alert”), and what sort of dialogue might follow. The designs will be trialled in these households, which have sufficient sensors installed that we will not need sophisticated analytics to infer what is going on. They will then be rolled out (after necessary modifications) to the “treatment” cohort

Summary

We have designed a process for creating an automated system to engage with users in dialogue about their activities that use energy and how these could be changed to meet users goals. It builds on insights from the literature on practices, engagement and user-interface design. The underlying infrastructure (sensor system, communication channels, database, tablet app) are in place and we have done preliminary work on the analytics and feedback/dialogue components. We are about to start recruiting households to the study, in three cohorts: co-designers, experimental condition, and controls.

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